NUHTD6
ISSN: 1040-7782

NUMERICAL HEAT TRANSFER

An International Journal of Computation and Methodology

PART A: APPLICATIONS

VOLUME 15 1989

NUMERICAL HEAT TRANSFER

An International Journal of Computation and Methodology

PART A: APPLICATIONS

Editor-in-Chief
W. J. MINKOWYCZ
University of Illinois at Chicago
Department of Mechanical Engineering
Chicago, Illinois 60680
(312) 996-3467/5317

Assistant to the Editor-in-Chief: **R. M. Szandra**

EDITORIAL ADVISORY BOARD

E. M. Sparrow, *Chairman*
Minneapolis, Minnesota

A. J. Baker, *Knoxville, Tennessee*
B. Berkovsky, *Moscow, USSR*
T. Cebeci, *Long Beach, California*
B. T. Chao, *Urbana, Illinois*
T. C. Chawla, *Argonne, Illinois*
P. M. Chung, *Chicago, Illinois*
S. W. Churchill, *Philadelphia, Pennsylvania*
G. Comini, *Udine, Italy*
G. de Vahl Davis, *Kensington, Australia*
E. R. G. Eckert, *Minneapolis, Minnesota*
A. F. Emery, *Seattle, Washington*
B. A. Finlayson, *Seattle, Washington*
T. Fujii, *Kasuga, Japan*
B. Gebhart, *Philadelphia, Pennsylvania*
J. Gosse, *Paris, France*
E. Hahne, *Stuttgart, FRG*
Y. Jaluria, *Piscataway, New Jersey*
S. Kotake, *Tokyo, Japan*
B. E. Launder, *Manchester, UK*
S. V. Patankar, *Minneapolis, Minnesota*
D. W. Pepper, *Aiken, South Carolina*
R. H. Pletcher, *Ames, Iowa*
G. D. Raithby, *Waterloo, Ontario*
P. J. Roache, *Albuquerque, New Mexico*
W. M. Rohsenow, *Cambridge, Massachusetts*
G. E. Schneider, *Waterloo, Ontario*
T.-M. Shih, *College Park, Maryland*
D. B. Spalding, *London, UK*
J. F. Thompson, *Mississippi State, Mississippi*
C. L. Tien, *Berkeley, California*
K. E. Torrance, *Ithaca, New York*
O. C. Zienkiewicz, *Swansea, UK*

Aims and Scope: *Numerical Heat Transfer, Part A: Applications* is an international vehicle for the publication of numerically based, results-oriented papers dealing with problems in heat transfer, mass transfer and fluid flow. The underlying numerical solutions may be based either on available methodology or on adaptations or moderate extensions of available methods. The presentation of experimental results which support the numerical solutions is also acceptable. However, papers whose main focus is on innovative numerical methodology development should be submitted to a companion journal, *Numerical Heat Transfer, Part B: Fundamentals.*

This journal will be published in two volumes, each containing four issues, for a total of eight issues scheduled for publication in 1989.

Abstracted and/or Indexed in: Current Contents, Information Service in Mechanical Engineering (ISMEC), Science Citation Index, Nova Information Services Co., and Engineering Information, Inc.

Editorial Office: W. J. Minkowycz, University of Illinois at Chicago, Department of Mechanical Engineering, Chicago, Illinois 60680.

Publishing, Advertising, and Production Offices: Publishing and Advertising: Hemisphere Publishing Corporation, 79 Madison Avenue, Suite 1110, New York, NY 10016-7892, (212) 725-1999, Elizabeth D'Costa, U.S. Marketing Representative; or Taylor & Francis Ltd., Rankine Road, Basingstoke, Hampshire RG24 0PR, England. Production: Hemisphere Publishing Corporation, 1101 Vermont Avenue, N.W., Suite 200, Washington, DC 20005-3521, Telephone (202) 289-2174, Carolyn Ormes, Production Editor.

Numerical Heat Transfer, Part A: Applications (ISSN 1040-7782) is published eight times per year by Taylor & Francis Ltd., 4 John Street, London WC1N 2ET U.K. for Hemisphere Publishing Corporation. Annual 1989 institutional subscription £241, US $410. Personal subscription rate available to home address only US $83.

Second-class postage paid at Jamaica, New York 11431. **U.S. Postmaster:** Send address changes to Numerical Heat Transfer, Part A, Publications Expediting, Inc., 200 Meacham Avenue, Elmont, NY 11003.

Dollar rates apply to subscribers in all countries except the UK and the Republic of Ireland, where the sterling price applies. All subscriptions are payable in advance and all rates include postage. Subscriptions are entered on an annual basis, i.e., January to December. Payment may be made by sterling check, dollar check, international money order, National Giro, or credit card (AMEX, VISA, Mastercard/Access).

Orders originating in the following territories should be sent directly to: **Australia**—R. Hill & Son, Ltd., 117 Wellington Street, Windsor, Victoria 3181. **India**—Universal Subscription Agency Pvt. Ltd., 101-102 Community Centre, Malviya Nagar Extn., Post Bag No. 8, Saket, New Delhi. **Japan**—Noriko Uda, Woodbell Incorporated, 4-22-11, Kitakasai, Edogawaku, Tokyo 134, Japan. **New Zealand**—R. Hill & Son, Ltd., Private Bag, Newmarket, Auckland 1. **USA, Canada, and Mexico**—Taylor & Francis, Inc./Hemisphere Publishing Corporation, 242 Cherry Street, Philadelphia, PA 19106-1906, USA. **UK and all other territories**—Taylor & Francis Ltd., Rankine Road, Basingstoke, Hampshire RG24 0PR, England.

Copyright © 1989 by Hemisphere Publishing Corporation. All rights reserved. Printed in the United States of America. Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by Hemisphere Publishing Corporation for libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of $3.00 per copy, plus .00 per page is paid directly to CCC, 27 Congress St., Salem, MA 01970, USA.

The publisher assumes no responsibility for any statements of fact or opinion expressed in the published papers or in the advertisements. **Numerical Heat Transfer, Part A: Applications** is owned by Hemisphere Publishing Corporation.

CONTENTS OF VOLUME 15

NUMBER 1

1 A Literature Survey on Numerical Heat Transfer (1986–1987) **Tien-Mo Shih**

33 Transient Condensation–Melting of a Subcooled Vertical Surface **D. Galamba and V. K. Dhir**

67 Three-Dimensional Laminar Natural Convection in a Honeycomb Enclosure with Hexagonal End Walls **Yutaka Asako, Hiroshi Nakamura, and Mohammad Faghri**

87 Laminar Mixed Convection in the Entrance Region of a Horizontal Annulus **Kailash C. Karki and Suhas V. Patankar**

101 Calculation of Forced Flow and Heat Transfer around a Cylinder in Crossflow **Wongee Chun and R. F. Boehm**

123 Finite Element Analysis of Transient Heat Conduction with Moving Convective Boundaries **M. F. Werner, M. A. Dokainish, and M. Shoukri**

133 Transient Conjugate Natural Convection Heat Transfer along a Vertical Plate Fin in a High-Porosity Medium **Chen-I Hung, Cha'o-Kuang Chen, and Ping Cheng**

NUMBER 2

149 Numerical Prediction of Heat Transfer and Fluid Flow in Rectangular Offset-Fin Arrays **Kanchan M. Kelkar and Suhas V. Patankar**

165 Laminar Flow and Conjugate Heat Transfer in Rib Roughened Tubes **T. M. Nguyen, J. M. Khodadadi, and N. S. Vlachos**

181 Effects of Anisotropic Heat Conduction on Solidification **J. A. Weaver and R. Viskanta**

197 Solidification of a Binary Alloy from a Cold Wire or Pipe: Modeling of the Mixed-Phase Region **Dimos Poulikakos and Wei-Zheng Cao**

221 The Brinkman Model for Natural Convection in a Shallow Porous Cavity with Uniform Heat Flux **P. Vasseur, C. H. Wang, and Mihir Sen**

243 Natural Convection Air Cooling of Heated Components Mounted on a Vertical Wall **M. Afrid and A. Zebib**

261 Natural Convection and Radiation in a Square Enclosure **A. Yücel, S. Acharya, and M. L. Williams**

NUMBER 3

281 Structure of Velocity and Temperature Fields in Laminar Channel Flows with Longitudinal Vortex Generators **M. Fiebig, U. Brockmeier, N. K. Mitra, and T. Güntermann**

303 Laminar and Turbulent Natural Convection-Radiation Interactions in a Square Enclosure Filled with a Nongray Gas **Toru Fusegi and Bakhtier Farouk**

323 Multigrid Solution of Natural Convection in a Vertical Slot **Natarajan Ramanan and Seppo A. Korpela**

341 Transient Natural Convection in a Cylindrical Enclosure Nonuniformly Heated at the Top Wall **S. K. Aggarwal and A. Manhapra**

357 Conjugate Conduction-Convection Heat Transfer Model for Four-Stroke Heat-Barrier-Piston Engines **David A. Blank and Tien-Mo Shih**

383 Solution of Nondeterministic Finite Element and Finite Difference Heat Conduction Simulations **J. Padovan and Y. H. Guo**

399 Groundwater Flow Effects in Processes of Soil Freezing **Andrzej Służalec**

NUMBER 4

411 Two-Dimensional Laminar Natural Convection Heat Transfer from a Fully or Partially Open Square Cavity **M. Miyamoto, T. H. Kuehn, R. J. Goldstein, and Y. Katoh**

431 Flow Structures Induced by Opposing Forces in Double-Diffusive Natural Convection in a Cavity **V. Sévéléder and J. P. Petit**

445 Forced Convection Heat and Mass Transfer from a Partially Liquid-Covered Surface **M. Kaviany**

471 Forced Convection Heat Transfer of Interacting Spheres **R. S. Ramachandran, C. Kleinstreuer, and T.-Y. Wang**

489 Laminar Flow and Heat Transfer in Blocked Annuli **Ajay K. Agrawal and Subrata Sengupta**

509 Direct Contact Heat Transfer to Bubbles with Simultaneous Translation and Growth **Y. Shimizu and Y. H. Mori**

525 Solution of Steady Periodic Heat Conduction by the Finite-Element Method **G. R. Zheng and S. C. Yang**

Following page 534:

Title Page to Volume 15
Contents of Volume 15
Author Index to Volume 15
Subject Index to Volume 15